2. Probabilistic Monitoring Networks

(1) General Considerations

DEQ's WQM Strategy includes a Probabilistic Monitoring (ProbMon) Module that is used to provide an unbiased statewide characterization of water resources. Such characterizations include conventional water quality parameters (dissolved oxygen, temperature, pH, and specific conductance/salinity), nutrients, bacteria and toxics in the water column, as well as the health of benthic communities and fish communities in the Commonwealth's surface waters. ProbMon's goal is to statistically assess the condition of all perennial freshwater rivers and streams in Virginia. The probabilistic survey sampling of this program is providing policy-makers and the public with:

(1) Estimates of the status of Virginia's aquatic resources with a known degree of statistical confidence,
(2) Estimates of trends and changes in indictors of Virginia's aquatic resources with a known degree of statistical confidence,
(3) Statistical summaries and assessments of Virginia's aquatic resources, and
(4) It will also facilitate the description of associations between indicators of natural and anthropogenic stress and aquatic resources.

A Virginia Joint Legislative Audit and Review Commission Report (JLARC, 1996) and subsequent Virginia legislation, such as Article 3.1§ 62.1-44.17:2 - 44.17:4 [III-A-1b-1a.doc] on Toxics Discharge Reduction and Article 4.01 § 62.1-44.19:4 - 44.19:10 [I-0d.pdf], the Water Quality Monitoring, Information and Restoration Act (WQMIRA - 1997), charge the Department of Environmental Quality with evaluating toxics in all of our state's waters, as well as with increasing our sediment, macro-invertebrate benthic, and fish tissue monitoring programs. They specifically encouraged increases in chemical and biological monitoring, increased statistical analysis of monitoring data, and consistent statewide sampling and comparisons for all water quality criteria. New probabilistic sites are selected for evaluation during each successive year of sampling, and the accumulation of sites, over time, allows characterizations of and statistical comparisons among smaller sub-populations of the Commonwealth's water resources.

DEQ has currently implemented separate probabilistic sampling designs for two specific classes of Virginia's water resources:

(1) Freshwater streams and rivers (free-flowing, non-tidal), and
(2) Tidal estuarine waters, consisting of Chesapeake Bay and tidal tributaries to Chesapeake Bay, the Atlantic Ocean, and Back Bay/North Landing River.

The Freshwater ProbMon Program has a statewide geographic distribution and includes participation by all of DEQ's Regional Offices. The Freshwater ProbMon Coordinator is located at DEQ's Blue Ridge Regional Office (BRRO) in Roanoke, and collaborates with monitoring staff at all Regional Offices and with the Biological Monitoring and Ambient Water Quality Monitoring Coordinators at the DEQ Central Office in Richmond. The geographic extent of the Estuarine / Coastal ProbMon Program is restricted to the eastern-most regions of the state. It is administered by the Estuarine ProbMon Coordinator at the DEQ Central Office in Richmond, in collaboration with DEQ's Chesapeake Bay Monitoring Program, and is carried out primarily by the Piedmont (PRO - Glen Allen) and Tidewater (TRO - Virginia Beach) Regional Offices. Beginning in 2007, the Northern Virginia Regional Office (NRO – Woodbridge) has accepted the

responsibility of sampling the few sites (0 to 3) that annually fall within Virginia's tidal embayments and tributaries to the Potomac River.

Current sampling designs include approximately 60 randomly selected sampling sites within freshwater and 50 sites within estuarine waters each year. This allows for the overall characterization of these two resource classes with associated margins of error approximately equal to plus or minus 12% and 14% of the estimate, respectively, on an annual basis. These margins of error decrease as the number of accumulated samples increases from successive years of sampling.

Because the freshwater and estuarine sampling programs differ somewhat in their basic designs, many specific elements of each are discussed separately below in Sections 2(b) – Free-flowing Freshwaters and 2(c) – Tidal Estuarine Waters. More general considerations and characteristics of the Probabilistic Monitoring (ProbMon) Program are discussed here.

The ProbMon sampling design provides answers to a wide variety of questions, including the basic ones in the following list, with a known degree of statistical accuracy. The list provided here is by no means exhaustive. It demonstrates, however, the kinds of questions that can be answered. The study design allows for both general and specific questions. General questions might be of most interest to decision-makers and managers in the development of new initiatives and in allocating workloads. More specific questions are appropriate for the management of a particular resource or for determining the variables that most affect the aquatic environment. The ProbMon survey seeks to answer the following types of questions, some of which may be more specifically directed either to freshwater or to estuarine resources.

General questions characterizing the Commonwealth's aquatic resources:

Policy: What water quality issues do policy makers need to address?
How effective are current management strategies at protecting resources?
How can efforts be redirected to better protect the most threatened resources?
Where is more stream protection needed?

Science: What is the current water quality statewide?
What impairments exist and how widespread are they?
What types of waters are most threatened and what are the threats?
What statewide and regional water quality trends exist?

Specific questions concerning the Commonwealth's aquatic resources:

How does water quality vary by ecoregion across the Commonwealth?
How many miles of river or estuary meet water quality standards?
How do land uses relate to aquatic resource quality?
What habitat characteristics are important for good water quality?
What percent of resources with degraded water quality are associated with the measured habitat indices?
For pollutants that are expensive to analyze, to what degree do they impair waters across the Commonwealth and where are the areas of concern?

General questions concerning benthic macroinvertebrate communities:

What are the best available conditions for the biological community?

What are the stressors to the biological community?
How do biological indicators correlate with stressors?
What proportion of ambient waters have balanced indigenous macroinvertebrate communities based on the available benthic metrics?
What are the critical habitat characteristics for healthy macroinvertebrate communities?

Specific questions concerning the benthic macroinvertebrate community:

Which biological metrics are indicative of specific stressors?
Can a matrix of ProbMon data be developed to identify reference sites and define reference conditions in Level III ecoregions?
Where are these Level III ecoregion reference sites?

Probabilistic monitoring will facilitate attaining WQM Strategy Objectives: 1-A (1 - 3, 5, 6), 1-B (7), 1-C (10), 3-(14) and 4-(19).

Why Use Probabilistic Survey Techniques?

There are various ways in which the quality of water resources could be evaluated in Virginia. One method would be to census all the streams in each drainage basin, which would be extremely expensive and time-consuming with about 80,000 kilometers (50,000 miles) of streams in the Commonwealth. A second method would be to use an empirical model for the water quality in each river basin. Models have to be calibrated and verified based on historical water chemistry records. Such models are also time-consuming and expensive, and currently are ineffective in determining the biological integrity of waters. A third way would be to collect data using targeted methods. Targeted monitoring networks have been in place in most States for decades and significant funds have been invested in collecting data from them. The monitoring stations are strategically located at places suspected of having degraded water quality. One example would be above and below the outfall of a wastewater treatment plant or permitted manufacturing facility. Traditionally, monitoring stations have also been placed where it is easy to sample. For example, most of Virginia's ambient monitoring stations have been established at bridges. Data collected in this manner can be used to answer local questions such as "Is a manufacturing facility in compliance with its wastewater permit?", "Is a specific facility significantly changing the water quality of a receiving stream?", or "Should the stream segment be on the Impaired Waters (303(d)) List?" While such targeted monitoring is excellent at answering these critical questions, it cannot be used to speculate on the overall condition of the Commonwealth's water resources. The reason is that the ratio of degraded to non-degraded waters is unknown. The probabilistic monitoring method offers an additional option, which is known to be capable of providing representative characterizations of all water resources in the state.

The probabilistic method allows DEQ to establish baseline water quality information for river basins, stream types, estuaries and geographic areas in the Commonwealth. If the probabilistic study is continuous or is repeated periodically, trends in the quality of water resources can also be estimated. Probabilistic monitoring can address regional questions such as "What percent of Virginia Piedmont steams have a pH lower than 6.5?" More important, the estimates can be made with statistical confidence. DEQ's ProbMon surveys collects data from approximately 300 free-running stream locations and 250 estuarine locations over a five-year period. This will provide statewide estimates for each sample parameter with a precision of ± 5%.

Why is it Important to Sample Randomly?

Much of the general discussion in the following section contains text modified from EPA's Answers to Frequently Asked Questions about R-EMAP.

Sampling Designs and Analyses (Vølstad et al. 1995).

The way we select a sample is crucial for obtaining accurate estimates of the parameters of interest. We clearly would not get a good estimate of the percentage of polluted streams in a watershed if we only sampled downstream from dairy farms. If dairies affect only a small percentage of the total stream length, this preferential sample would include a much higher proportion of nutrients, sediment, and bacteria than the general population of streams. This kind of sampling provides useful information about conditions downstream of dairies, but it does not produce estimates that accurately represent the whole watershed.

The historical tendency has been to extrapolate data/results from subjectively selected sites to holistic conditions for which they are unsuited. Preferential selection can be avoided by taking completely random samples. Simple random sampling ensures that no particular portion of the sampling universe (e.g., kinds of river reaches) is favored. By this method, the chance of selecting a sampling unit with degraded conditions is proportional to the number of sampling units in the target population that are degraded. For example, if 20% of the target population has degraded conditions then, on average, 20% of the (randomly selected) units in the sample will exhibit degraded conditions. This property of random sampling allows estimates to be used to draw conclusions about the target population as a whole.

Purpose

At the global level, the Virginia DEQ has defined its agency goals and objectives relative to its comprehensive statewide Water Quality Monitoring (WQM) Program. Probabilistic monitoring will facilitate attaining WQM Strategy Objectives: I.A (1 - 3, 6) and I.B (7), as described earlier in this document. Probabilistic monitoring is considered a high priority monitoring activity. All of the DEQ regions need to complete their assigned probabilistic stations in order for DEQ to reach defensible conclusions about water quality from a statewide perspective.

Periodic Review of Program

The five-year EPA grant supporting the Coastal 2000 / National Coastal Assessment estuarine probabilistic monitoring program expired in the fall of 2004, and the first five-year block of freshwater probabilistic monitoring was completed in the fall of 2005. A Probabilistic Monitoring Workgroup was established within the agency to evaluate both the freshwater and estuarine ProbMon programs, and to define the direction that each would take in subsequent years. Among the subjects that were considered were the parameter coverage and the annual numbers of sites that could be maintained with the decline in monitoring resources that has been experienced in recent years. During the winter and spring of 2003-2004 this workgroup considered a number of viable adaptations of both ProbMon programs and provided recommendations to DEQ administrators in the summer of 2004. These recommendations have been integrated into the descriptions that follow of the two separate programs.

The value of the probabilistic monitoring programs was reevaluated in 2012 during discussions about adaptations to further declining resources. The Probabilistic Monitoring Programs were rated among the top four in terms of priority for maintaining the maximum effort feasible under existing conditions. At the present time (March 2013) the integration of DEQ General Funds with Federal §106 Supplemental Grants

(targeted supplement for Strategy Development and the rotating NARS surveys) provide sufficient resources to maintain the Programs at their established level of approximately 50 to 60 new freshwater sites and 50 new estuarine sites per year.

(2) Probabilistic Monitoring of Free-flowing Freshwaters

The DEQ Biological Monitoring Program initiated the freshwater probabilistic sampling of this module in the spring of 2001. Since that time, the agency has been sampling 40 to 50 new probabilistic freshwater sites each year. Thirty additional sites were randomly selected as probabilistic trend sites. Fifteen sites of the thirty sites are sampled each year. In the freshwater resource class, the distribution of site selection among stream sizes has been chosen to ensure approximately equal representation among five sampling strata: streams of the 1st, 2nd, 3rd, 4th, and ≥5th Strahler Orders. In wadeable streams, DEQ collects biological samples and measures conventional field parameters (temperature, dissolved oxygen, pH and conductivity) during separate spring and fall visits to each site. This provides for the evaluation of seasonal variations at the site and will ensure that field parameters and biological information are collected during two critical periods for the principal groups of water quality parameters of interest. For sites in this resource class, spring and fall sampling coincides with high- and low-flow periods, respectively, providing evaluations of worst-case and best-case NPS scenarios, as well as two different phases of benthic organism life cycles. In non-wadeable streams, the randomly selected sites are visited in the spring and the fall, but larger boatable river sites are only sampled in the fall. Where feasible, monthly water quality stations have now been established near many freshwater probabilistic sites to collect additional information on highly variable parameters.

As mentioned above, the agency performs its most complete chemical monitoring at probabilistic sites. This is especially true for the more expensive analyses of toxic compounds. At present, sediment organic chemical and metals monitoring have been suspended due to lack of funding. Freshwater probabilistic sites are also where DEQ performs its most extensive habitat assessments and land use characterizations, to evaluate effects of habitat conditions and alterations on the benthic community. Because of the unbiased, random design of the ProbMon site selection process, the results provide interval estimates (an ‘average’ value ± a margin of error) of statewide stream conditions within the corresponding water resource class (classes).

(i) Program Strategy

Freshwater ProbMon’s goal is to statistically assess the condition of all non-tidal, perennial streams in Virginia. The initial five-year survey was evenly spread over the period 2001-2005 and incorporated results from wet, dry, and normal years into the database. The agency has committed to make this activity a permanent part of our monitoring strategy. The survey provided policy-makers and the public with estimates of the status of Virginia’s aquatic resources with a specified degree of statistical confidence. It has been employed to detect and describe the relationships between various indicators of natural and anthropogenic stress and the condition of associated aquatic resources. Finally, it has been used to generate statistical summaries and evaluations of the Commonwealth’s surface water resources, and to identify emerging threats to regional water quality. The incorporation of results from the freshwater ProbMon Program has become a regular feature of DEQ’s biennial Integrated 305(b)/303(d) Water Quality Assessment Reports.

(ii) Monitoring Objectives

The objectives of ProbMon's freshwater survey are to provide policy-makers and the public with the various types of information required for representative ecological characterizations of Virginia's non-tidal streams and rivers:

(1) Estimates of water resource conditions, and their geographic extent, with a known degree of confidence;
(2) Estimates of the current status, trends, and changes in indictors of Virginia's water resources with a known degree of confidence;
(3) Statistical summaries and characterizations of Virginia's regional and statewide water resources; and
(4) A description of the degree of association between indicators of natural and anthropogenic stressors and the condition of water resources.

Probabilistic monitoring facilitates attaining WQM Strategy Objectives: I.A (1 - 3, 6) and I.B (7), as described earlier in this document. Probabilistic monitoring is considered a high priority monitoring activity. All DEQ regions need to complete their assigned probabilistic stations in order for DEQ to make defensible conclusions about water quality from a statewide perspective.

(iii) Monitoring Design

The selection of probabilistic sampling sites for this sub-module is accomplished by computer, using EPA / EMAP protocols. In 1999, DEQ provided information to EPA on the specific objectives of the study, the type(s) of aquatic resources to be sampled and the weighting (relative numbers of samples) desired for each resource subclass. EPA/ORD's National Health and Environmental Effects Research Laboratory (NHEERL) - Western Ecology Division, Corvallis, OR, subsequently provided a list of five annual groups of randomly selected geographical coordinates to be sampled within each stream size class (Strahler Stream Order). Lists of the sites sampled in 2001 through 2005 are provided in the Table "Freshwater ProbMon Sites 2001-2005" [III-A-1b-2-2.xls]. A list of prospective sites for 2006 through 2010, along with a map showing counties and Level III Ecoregions is provided in Prospective Freshwater Probabilistic Sites for 2006 Through 2010 [III-A-1b-2-5.xls], and Prospective Freshwater Probabilistic Sites for 2011-2020 are in [III-A-1b-2-6.xls]

(iv) Core and Supplemental Water Quality Indicators

To obtain an idea of the water quality across the Commonwealth, field and chemical data are collected at each ProbMon site following DEQ's Standard Operating Procedures (see WQM SOP Manual). Dissolved oxygen, pH, specific conductance, and temperature are measured in mid-stream at 0.3 m below the water surface. Water and sediment samples are collected and sent to the Virginia Division of Consolidated Laboratory Services (DCLS) in Richmond, Virginia, for analysis ("Matrix of Parametric Coverage" [III-A-0b.xls] FP = freshwater ProbMon, spring & fall). At present (2013), a minimum of 87 chemical and physical parameters is measured at each site, including the four field parameters.

ProbMon collects biological monitoring data at wadeable sites using EPA's Rapid Bioassessment Protocols (RBP) for benthic macroinvertebrates. ProbMon biomonitoring differs from DEQ's historical approach, in which monitored sites were paired with a single reference site to characterize the expected condition of undisturbed biota. A goal of DEQ's biomonitoring program is to switch from using site-specific reference stations to a statistically derived reference condition based on multiple reference sites. Such a multimetric

index for macroinvertebrate communities allows more robust and statistically defensible comparisons. The data collected at random sites in the ProbMon program are accelerating this process and helping to determine reference conditions throughout the commonwealth. Refer to the discussion on the Virginia Stream Condition Index (SCI) in Section III-B-4 – 'Biological Monitoring Program' later in this chapter.

The Virginia ProbMon survey includes a habitat assessment component to determine the percent of non-tidal streams that are degraded, as well as the percent that have exceptional quality. Habitat data are collected using EPA's RBP visual habitat assessment methods. These methods use qualitative scoring that is subjective, but comparable statewide when performed by trained biologists. For higher gradient streams, a quantitative habitat assessment has been added that allows not only an assessment of existing sediments present in the stream, but also facilitates calculating an estimate of the type of sediment the stream should contain under 'natural' conditions. The goal of collecting these quantifiable physical habitat data is to separate the differences between anthropogenic and geologic processes in stream channel adjustment (Rosgen, 2001). One of the more elusive parameters to quantify is increased sediment supply to streams (Kappesser, 2002). According to Rosgen several factors control river channel form, principally stream flow, sediment regime, riparian vegetation, and direct physical modifications. The methods currently being employed can detect an increase of sediment supply over that characteristic of natural conditions.

Another component of the freshwater ProbMon program is the calculation of land cover estimates upstream from ProbMon sites. The land use surrounding a water body can significantly impact the in-stream water quality, also altering the physical habitat and the biological community. DEQ is in the process of creating a filtering matrix (which includes habitat and chemical data) to identify potential reference sites using Land Cover data. As ProbMon evolves, the quantity and variety of habitat data collected will expand to better define the range of physical habitat, and to allow the detection of relationships between biological communities, physical habitat, land cover and water quality.

(v) Data Management

All water and sediment chemical results are stored in DEQ's Comprehensive Environmental Data System (CEDS). Using Oracle Discoverer, the water chemistry data is retrieved as an Access database file and put into an Arc View 3.2 Geographic Information System (GIS) database to generate maps. All biological and physical habitat data are stored in the Ecological Data Application System (EDAS), an Access database developed by the consulting firm TetraTech, Inc. The ProbMon data in EDAS is queried and merged into the GIS database to complement the chemical data. Migration of the data to GIS makes it possible to identify the ecoregion of each station, adjacent land use, and spatial patterns. All data is combined in an Access database to facilitate importing to statistical packages.

Following the first year of freshwater probabilistic monitoring, in the spring and fall of 2001, DEQ produced its first Probabilistic Monitoring (ProbMon) Report. Several more comprehensive reports have since been produced, including sections in DEQ's biennial 305(b)/303(d) Integrated Reports, and a number of presentations have been made at local and national meetings. These reports and others are available on the DEQ Probabilistic Monitoring WebPages.

Future Freshwater ProbMon Reports will be posted at the same Website address, as they become available. The results of DEQ's Probabilistic Monitoring Program are also summarized biennially in each 305(b)/303(d) Integrated Water Quality Report, beginning with the 2008 edition.

For further information about the Freshwater Probabilistic Monitoring Program Contact:

Jason Hill
Freshwater ProbMon Coordinator
DEQ Blue Ridge Regional Office
3019 Peters Creek Road
Roanoke, VA 24019
(540) 562-6724
Jason.Hill@deq.virginia.gov

(vi) Data Analysis / Assessment

Probabilistic monitoring data analyses are performed following EPA guidelines. Following these methodologies has already provided statewide estimates for many water quality parameters.
One method of analysis involves the arrangement of the data to generate the cumulative distribution function (CDF) for key variables. The CDF is a statistical function that in the past has been under-utilized in environmental studies. Formally, it estimates the probability that a variable is less than or equal to some value. This function is most useful when displayed graphically. Then the viewer is able to determine the likelihood that a variable would be less than a particular threshold. However, it can also provide the probability that a variable would be above a threshold or that it would be within a certain range. For DEQ's ProbMon, these probabilities apply to the target universe; all non-tidal streams in the Commonwealth.

CDF development begins with the probabilities used in the random selection of sample sites. A. Olsen (EPA/ORD, Corvallis, OR) provided these probabilities based on DEQ's request that a random survey be designed for the network of all non-tidal streams in Virginia (A. Olsen personal communication 2000). An unequal probability survey design was requested such that Strahler stream orders 1, 2, 3, 4, and ≥5 had equal probabilities of being sampled. The sample probability, also called the inclusion probability and symbolized by π_i, was different for each i^{th} Strahler order. The inverse of the inclusion probability, the initial design weight, is listed for each Strahler order in Table G2 of Appendix G of the first year ProbMon Report (p 183) [III-A-1b-2-4.pdf].

In a probabilistic survey the population parameter to be estimated is the total of the variable over the target universe. As an example, for pH we seek to estimate the sum of pH observations over all non-tidal streams in the Commonwealth. For a discrete resource the total is as follows:

$$\hat{z}_T = \sum_{i=1}^{n} \frac{I_R(s_i) z(s_i)}{\pi(s_i)}$$

This is a general population parameter that can be used to estimate the mean, variance, and distribution functions for each sampled variable over the target universe, because each statistic depends on the total or sum of z.

The distribution of the parameter of interest may be characterized with known inclusion probabilities through a Cumulative Distribution Function (CDF) curve using the Horvitz-Thompson Estimator (Diaz-Ramos et al. 1996 [III-A-1b-2-4a.pdf]). The CDF curves are calculated on this basis using R routines available at the EMAP web address. The mathematical description of the CDF function for generating the curve for parameter 'z' in stratum 'h', and in year 't', is represented as follows (USEPA, 2002).

$$\hat{F}_{th}(z) = \frac{1}{n_{th}} \sum_{i;1}^{n_{th}} I\{z_{thi} \le z\}$$

Here, '$\mathbf{z_{thi}}$' is the measurement on the parameter in year '**t**', from stratum '**h**', at sample site '**i**', and $\mathbf{n_{th}}$ denotes the number of observations in year **t** from stratum **h** (Rathbun et al., 1996). In this report, the stratum is a constant because there was no stratification necessary. The variance of

$$\hat{F}_{th}(z)$$

is approximately the following (USEPA, 2002)

$$\hat{V}_{HT}(\hat{z}_T) = \sum_{s_i \in R} \frac{z^2(s_i)}{\pi^2(s_i)} + \sum_{s_i \in R} \sum_{\substack{s_j \in R \\ j \neq i}} \left[\frac{\pi(s_i, s_j) - \pi(s_i)\pi(s_j)}{\pi(s_i, s_j)\pi(s_i)\pi(s_j)} \right] z(s_i) z(s_j)$$

For the CDF curve to provide accurate probabilities, the statistics used to support its calculation must be appropriate, and the data must be collected properly. The USEPA has developed applications for producing the CDF function for probabilistic data. The statistical details can be found in the EMAP Statistical Methods Manual (Diaz-Ramos et al. 1996). This manual does not explain how to weight observations. The necessary details are covered comprehensively by Tony Olsen's document "Adjusting Weights" (A. Olsen, draft document 3/25/2002). For information on adjusting design weights (inclusion probabilities) see Appendix G of the first year ProbMon Report. For CDF background information the reader is referred to the EMAP web site at http://www.epa.gov/nheerl/arm/analysispages/techinfoanalysis.htm. It provides examples of probabilistic studies, applications, and the EMAP methods manual. It also provides software for adjusting site weights, generating CDFs, and producing summary statistics based on probabilistic environmental data.

(vii) Reporting requirements

Following the first year of freshwater probabilistic monitoring, in the spring and fall of 2001, DEQ produced its first Probabilistic Monitoring (ProbMon) Report. Several more comprehensive reports have since been produced, including sections in DEQ's biennial Integrated Reports, and a number of presentations have been made at local and national meetings. These reports and others are available on the DEQ Probabilistic Monitoring WebPages.
[http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/ProbabilisticMonitoring.aspx]

Future ProbMon Reports will be posted at the same Website address, as they become available. The results of DEQ's Probabilistic Monitoring Program are also summarized biennially in each Water Quality Integrated Report, beginning with the 2008 edition.

(viii) Periodic Review of Program

ProbMon is subject to periodic internal and external reviews. The freshwater ProbMon program sends copies of reports to EPA staff including Dr. Anthony Olsen (EPA, ORD) and USEPA Region 3 Freshwater Biology Team Staff. DEQ staff has also requested the agency's Academic Advisory Committee (AAC) to review ProbMon reports. Insightful discussions have already occurred with AAC staff members in regard to future ProbMon goals. DEQ staff has also made presentations about the program at national and regional

conferences. Future ProbMon reports, which will more effectively transfer useful information to the general public, are being planned.

(ix) General Support and Infrastructure

The Commonwealth of Virginia and EPA 106 grants currently provide resources for all freshwater ProbMon activities. Regional monitoring staffs collect all of the necessary data and regional assessment staffs perform data analysis and produce unified ProbMon reports. EPA has provided the periodic five-year lists of ProbMon monitoring site selections, statistical analysis training, and technology transfer of qualitative habitat methodologies (by EPA Region III Laboratory).

Freshwater Probabilistic Monitoring – 2013 and Beyond

Virginia's free-running freshwater probabilistic monitoring network (ProbMon) is intended to be a thorough environmental assessment of 50 to 60 randomly chosen stream sites each year. The goal is to assess the site's chemical, physical and biological attributes, along with land-use characteristics, to provide a comprehensive environmental assessment. Because the sample locations are randomly chosen, these assessments can be used to make estimates of statewide and regional conditions. In addition to making estimates of how many river miles do or don't meet water quality criteria, it will also be possible to identify types of streams that are most at risk for different stressors and to calculate correlations between chemical, physical and biological conditions and land uses. An additional goal of this program is to identify emerging threats to our environment.

The agency piloted the probabilistic program from 2001 to 2005 and has committed to make this activity a permanent part of our monitoring strategy. . The state monitoring design has been integrated into the 2013-2014 National Stream and River Assessment survey (NSRA) and the agency plans on participating in the 2018-2019 NSRA project. The agency would like to fund real-time temperature data collection at all probabilistic sites. Two additional goals of the freshwater probabilistic program are to create a fish community biotic index and reestablish the monitoring of toxic chemicals.

Beginning in 2013, the Freshwater Probabilistic Monitoring Program is being enhanced by a modification in the use of resources from the Ambient Watershed Station Network. At carefully selected freshwater probabilistic sites in each DEQ region, watershed stations are being established within the same homogeneous reach of the stream. These adapted watershed stations will be sampled monthly for a period of one year, using a new sub-program code (PA), in order to characterize temporal variability of conventional field, nutrient, and bacterial parameters at probabilistic sites. Although the year 2013 is considered to be a pilot study, to evaluate and improve the new sub-program, the intent is to rotate sites annually throughout the next six-year rotation cycle (2013-2018).

Contact: For further information on freshwater probabilistic monitoring contact:

Jason Hill
ProbMon Coordinator
3019 Peters Creek Road
Roanoke, Virginia 24018
(540) 562-6724
Jason.Hill@deq.virginia.gov

or

Lawrence D. Willis, Ph.D.
Technical Services Supervisor
3019 Peters Creek Road
Roanoke, Virginia 24018
(540) 562-6825
Larry.Willis@deq.virginia.gov

(3) Probabilistic Monitoring of Tidal Estuarine Waters

Virginia's estuarine probabilistic monitoring module was initiated in the summer of 2000 with a five-year grant (CR-828544-01) from EPA's "National Coastal Assessment (NCA) Program", initially known as the "Coastal 2000 Initiative" (C2). The two terms are used interchangeably in this document. That original, five-year effort was defined under the terms of a proposal titled "Monitoring the US Atlantic Coast: Assessing Virginia's Estuaries and Tidal Tributaries to the Chesapeake Bay and the Atlantic Ocean" [III-A-1b-3-1.doc], submitted to the US-EPA in the spring of 2000. The most current (2013) specific field methodologies and quality assurance requirements of the Coastal 2000 / National Coastal Assessment Program are described in the EPA documents "National Coastal Assessment Field Operations Manual" [III-A-1b-3-2.pdf] (EPA-841-R-09-003) and "National Coastal Condition Assessment Quality Assurance Project Plan" [III-A-1b-3-3.pdf] (EPA No. 841-R-09-004).

The resources provided by the initial five-year grant, as well as periodic EPA site visits, national conferences and regional technology transfer workshops, allowed the Virginia DEQ to initiate its Estuarine Probabilistic Monitoring (ProbMon) Program with the purchase of field equipment and the training of agency coordinators and field personnel. A subsequent, two-year interim grant (CR-83270801-1 2005-2006) eased the transition of the Coastal 2000 Initiative from an experimental program, under the auspices of EPA's Office of Research and Development (ORD), to a successfully established program under the auspices of the EPA Office of Water (OW). DEQ recognizes the value of its Estuarine ProbMon Program, and has adapted the original design in order to continue the program with the more limited resources available from State general funds and through the §106 grant process. More details relative to this transition are provided below.

The National Coastal Condition Assessment (NCCA) Program has now become one element of the National Aquatic Resources Survey (NARS) Program, which rotates among five resource classes, (1) wetland, (2) stream and (3) river, (4) lake, and (5) coastal resources on a five-year cyclic basis. The first occurrence of the NCCA Survey in this cycle was in 2010, and coastal resource surveys are scheduled to reoccur at five-year intervals (2015, 2020, etc.). In 2010, DEQ integrated agency general funds with federal grants provided by the CWA §106 and the NARS/NCCA Programs to extend its coastal survey to near-shore oceanic waters, from barrier beaches out to the three-nautical-mile territorial limit. Logistical support and additional human resources for this survey were provided by EPA in the form of its Oceanic Survey Vessel (O.S.V.) Bold and crew, and field personnel from EPA National Headquarters (Washington, DC) and EPA Region 3 Headquarter (Philadelphia, PA). Details of this survey and its results were included in DEQ's 2012 305(b)/303(d) Integrated Water Quality Report , of which Chapter 4.8 "2010 Near-shore Oceanic Survey" [III-A-1b-3-3a] is linked to this document. Ideally, such near-shore surveys would also be repeated at five-year intervals in synchrony with the scheduled NCCA surveys, but current trends in resource availability are not encouraging.

The geographic extent of the Estuarine ProbMon Program is restricted to the coastal plain of the eastern-most regions of the state. It is coordinated through the DEQ Central Office in Richmond and is carried out primarily by the Piedmont (PRO - Glen Allen) and Tidewater (TRO - Virginia Beach) Regional Offices. A few of the estuarine probabilistic sites fall in Virginia's tidal Potomac River embayments and tributaries, within the geographic jurisdiction of the Northern Virginia Regional Office (NRO - Woodbridge). Initially, because of the small number of sites involved (0 to 3 sites annually), and logistical and training considerations, PRO assumed the primary responsibility for sampling there, although NRO personnel at times accompanied and aided them in the field. Beginning in 2007, NRO assumed all responsibility for sampling at probabilistic estuarine sites within their portion of the Potomac River basin, and at times aids

PRO by assuming the responsibility for other Potomac River sites lower in the estuary. In late May of 2010, field personnel from all three regional offices (NRO, PRO and TRO) participated in the NCCA Field Training session in Virginia Beach.

The discussion that follows is focused primarily on the well-established annual estuarine surveys of state design, with periodic modifications (five-year intervals) prescribed by NARS/NCCA national program designs.

(i) Purpose

The original goals of the National Coastal Assessment (Coastal 2000) Program were summarized as:

(1) Assess the ecological condition of estuarine resources,
(2) Determine reference conditions for ecological responses/stressors, and
(3) Build infrastructure in EPA Regions and participating states.

Additional, more specific federal objectives were to:

(4) Assess the health or condition of the estuarine waters of the United States and trace changes in that condition through time,
(5) Assess the health or condition of the estuarine waters of the various coastal states and trace changes in that condition through time,
(6) Utilize the approach to identify reference conditions for estuarine waters in the United States, and
(7) Utilize existing state monitoring programs as appropriate.

At the state level, the Virginia DEQ defined its agency goals and objectives relative to its comprehensive statewide Water Quality Monitoring (WQM) Program. Estuarine probabilistic monitoring facilitates attaining WQM Strategy Objectives: I.A (1-3, 6) and I.B (7), as described earlier in this document. Estuarine probabilistic monitoring (ProbMon) is considered a high priority monitoring activity. Each participating DEQ region (Piedmont, Tidewater and Northern Virginia Regional Offices, in this case) needs to complete its assigned probabilistic stations in order for DEQ to reach defensible conclusions about estuarine water quality from both statewide and basin by basin perspectives. Additional specific details about the Probabilistic Monitoring (ProbMon) Program in general are presented above, in the section on Probabilistic Monitoring Network – General Considerations.

(ii) Monitoring Design

For the Coastal 2000 Initiative the sampling strata for tidal tributaries were originally geographically defined by estuary size: (1) <100 km^2, (2) 100 – 250 km^2, and (3) >250 km^2, and subsequently by drainage location (Chesapeake Bay drainage vs. Atlantic Coastal drainages). Upon DEQ request, an annual set of randomly selected sampling locations (and alternates) was provided by EPA/ORD. Prior to 2005, these lists were generated at the Gulf Ecology Division (GED) Laboratory in Gulf Breeze, Florida, which coordinates the Gulf and Southeastern Regions of the National Coastal Assessment Program. In 2005 Virginia (as well as Maryland) was transferred from the Southeastern to the Northeastern Region, and site selections subsequently were provided by the Atlantic Ecology Division (AED) Laboratory in Narragansett, Rhode Island. The AED provided Virginia with its site list in 2005 and 2006. In the spring of 2007, AED provided Virginia with programmed script and orientation for using the "R" language and free access software to generate its own annual site lists, and DEQ has continued to do so for its state design surveys. The only

exceptions have been and will continue to be when the NARS national design is superimposed on DEQ's state design.

The two principal sampling strata for attaining DEQ's state objectives consist of: (1) minor tidal tributaries to the Chesapeake Bay and to its major tidal tributaries and (2) tidal tributaries and embayments of the Atlantic coast (Delmarva) and Back Bay/North Landing River (which discharge into Pamlico/Albemarle Sounds, North Carolina). The agency believes the major tidal tributaries to Chesapeake Bay (James, York, and Rappahannock River mainstems) and the Bay mainstem itself are effectively characterized by the probabilistic monitoring of Virginia's Chesapeake Bay Program. These mainstems are generally included in the annual DEQ sampling design only at five-year intervals (see section below on 'Rotating National Probabilistic Surveys). The mainstem of the Potomac River estuary is almost exclusively within Maryland's territorial jurisdiction.

In the first year (2000) of the Coastal 2000 Initiative sampling, 35 random sites were selected in Virginia's portion of the Chesapeake Bay mainstem and the tidal portions of its major tributaries (Rappahannock River, York River, James & Elizabeth Rivers). The tidal portions of the Potomac River mainstem are almost entirely in the state of Maryland, although tidal embayments and tributaries on the Virginia shore are included in Virginia's sampling design. In order to better characterize smaller estuarine subdivisions, DEQ has in subsequent years emphasized, and will continue to emphasize, minor tidal tributaries to the Chesapeake Bay, the Atlantic Ocean, and to Pamlico/Albemarle Sound by sampling at 50 sites annually. Virginia's participation in the interstate Chesapeake Bay Program already provides adequate probabilistic benthic monitoring for the characterizations of the Chesapeake Bay mainstem and its major tidal tributary mainstems (e.g., lower Potomac, Rappahannock, York, and James Rivers). The weighting of the current sampling design guarantees that each year approximately 70% of the sites (35 stations) are selected in the Chesapeake Bay drainage and approximately 30% (15 sites) are selected in coastal drainages. This will assure that a minimum of approximately 75 sites will be available to characterize the Atlantic Coastal resource class during each five years of the program. The table of Estuarine & Oceanic Probabilistic Stations [III-A-1b-3-4a.xls] presents a descriptive summary of the Coastal 2000 / National Coastal Assessment / DEQ Estuarine ProbMon sites that were sampled from 2000 through 2012 of the program.

At its spring 2003 EMAP Conference in Newport, Rhode Island, soon before the conclusion of the initial five-year grant period, EPA announced that the Coastal 2000 Initiative, previously considered an experimental program, was judged to be a success and would be transferred from the Office of Research and Development (ORD) to the Office of Water (OW), as the newly established National Coastal Assessment Program. The availability of a two-year interim grant to continue the program during this transition period (2005-2006) was announced in late 2004. Concomitant with this transition, the states of Maryland and Virginia were transferred from the Southeastern Regional Coordination Center (ORD/GED – Gulf Ecology Division - Gulf Breeze, FL) to the Northeastern Regional Coordination Center (ORD/AED – Atlantic Ecology Division - Narragansett, RI), and additional survey design requirements were announced. During the two-year transition period, with annual resources reduced to 50% of the previous level, the NCA design annually included 25 sites per state, in Virginia 20 of which fell within the Chesapeake Bay drainage (including Bay and major tributary mainstems) and 5 of which fell within coastal estuarine waters. In order to prevent duplication of effort and to minimize resource requirements, the 20 random NCA sites within the Bay and its tributaries were integrated into the normal sampling design of the Chesapeake Bay Program's probabilistic Benthic Monitoring Program. During the two-year transitional period, all water column and sediment sampling conducted at the 20 annual mainstem sites was carried out by the Benthic Ecology Laboratory of Old Dominion University (ODU), Norfolk, under the auspices of Dr. Daniel M. Dauer. To complement the national design and attain state objectives, Virginia requested an additional 25 random sites following its previous sampling design (2001-2004), with 70% in minor tidal tributaries of the

Bay drainage and 30% in coastal estuarine waters. DEQ provided the additional resources to sample and analyze all water column and sediment parameters at these sites, to include benthic infauna but exclude fish community and fish tissue collection and analyses. EPA generously permitted access to its nationally contracted analytical services to provide more economical chemical and toxicological analyses of sediment samples from the additional sites. This maintained monitoring efforts within Virginia's estuarine waters at the previously established level of 50 sites per year. The station lists for the two-year transitional period (2005-'06) are included in the table of Estuarine Probabilistic Stations [III-A-1b-3-4a.xls].

From 2007 through 2009, DEQ continued to sample using the Virginia state design with 50 sites annually, 35 within the Chesapeake embayments and minor tributaries and 15 in Coastal Delmarva and the Back Bay region. The NCCA design was again used in 2010, in the first five-year cycle of the National Aquatic Resources Survey (NARS). Twenty-two National design sites were selected from Virginia waters, twenty within the Chesapeake Bay watershed, one from Delmarva coastal, and one from Back Bay. The NCCA Program also provided an updated set of Site Evaluation Guidelines [III-A-1b-3-2a.pdf] for the 2010 NARS Survey. One additional alternate site was utilized in the tidal freshwater portion of the James River because a Chesapeake mainstem site was shoaled and could not be sampled from the large ODU vessel being utilized in the mainstem. DEQ suspended its state design that year to apply the resources to a Near-shore Oceanic Survey. EPA NHEER, Corvallis, OR provided the selection of 50 completely random primary and 50 alternate sites between barrier beaches and the three-nautical-mile Virginia territorial limit. As mentioned above, fifty sites were sampled from EPA's Oceanic Survey Vessel, the O.S.V. Bold, from 15 through 18 August, 2010. The suite of parameters analyzed from this survey was identical to those analyzed in the 2010 NCCA survey, with one exception. State and federal resources were insufficient to include fish trawls and fish tissue chemical analyses in the oceanic survey.

In 2011 and 2012 DEQ returned to its normal state design surveys of 50 estuarine sites annually, and will continue to do so for the foreseeable future, with the exception of integrating with the scheduled NCCA surveys at five-year intervals (2015, 2020, etc.).

(iii) Core and Supplemental Water Quality Indicators

With the resources provided by the original EPA Coastal 2000 / NCA Grant, from 2000-2004, estuarine probabilistic stations were sampled for the complete suite of parameters described in the National Coastal Assessment QAPP [III-A-1b-3-3] cited above, as well as for several additional parameters utilized by the Chesapeake Bay Program. The total suite of water column parameters included hydrographic profiles of temperature, pH, DO, salinity and Photosynthetically Active Radiation (PAR), as well as samples for nutrients, chlorophyll-a and suspended solids analyses at near-surface, mid-depth and near-bottom. In addition, homogenized sediment samples were collected for local (DCLS) analyses of particle size and total organic carbon (TOC), as well as for metals and organic contaminant analyses and toxicity testing at EPA-contracted laboratories. A separate, 0.04 m^2 sediment sample (at least seven centimeters in depth) was collected, sieved and preserved in the field for the posterior identification of benthic macroinvertebrate infauna species, to complete the 'Sediment Quality Triad' (SQT) for toxics-related 'weight-of-evidence' evaluations and assessments. EPA Grant funds also provided for the contracting of the Fisheries Science Laboratory at the Virginia Institute of Marine Science (VIMS) for fish trawl surveys to collect fish community-structure data, epibenthic organisms, incidental fish with external abnormalities for pathological examinations, and targeted fish species for the analyses of metals and organic contaminants in fish tissues. Because of resource limitations in 2005 and 2006, fish trawl surveys were only conducted at the 25 sites specified in the national survey design. The inclusion of fish trawl surveys in future estuarine probabilistic monitoring efforts is discussed more fully below. (Please refer to the "NCA-C2000 Overview" [III-A-1b-3-5.pdf] for a summary of the core ecological and chemical parameters stipulated by the National

Coastal Assessment (Coastal 2000 or C2) Program and "Parametric Coverage" [III-A-0b.xls], under Program Code C2 - Coastal 2000, for a complete list of locally analyzed water column and sediment parameters.) Beginning in the summer of 2003, DEQ supplemented the NCA core indicators at most sites with additional sampling for bacteria (fecal coliform bacteria, *E. coli*, and *Enterococci*), and with dissolved and total trace metals from 2008 through 2011. Because no chronic trace metal standards violations had been observed, water column trace metal sampling was suspended in 2012 to devote the resources to another program.

Sample handling and shipping have varied with the type of sample and its final destination for analysis. All samples are collected from boats anchored at the monitoring sites and are appropriately labeled and submerged in wet ice at 4^{o}C during transport to the responsible DEQ Regional Office or contracted laboratory. Samples to be analyzed at the Virginia state laboratory (DCLS) are maintained on ice and shipped daily to Richmond by overnight courier service. Such samples are received and processed within 24 hours of collection. Whatever questions arise concerning the location, date, time or depth of samples arriving at DCLS, or about the accuracy of associated data transmitted from DEQ's CEDS database to the SIMS database at DCLS, are resolved immediately via e-mail and voice communication between laboratory personnel and monitoring personnel at the DEQ Central Office or appropriate Regional Office. Analyses are completed within the holding times specified in the pertinent QAPPs and EPA analytical method descriptions, after which the resultant data are entered into the DCLS LIMS system. Analytical results passing quality assurance evaluations are subsequently transmitted to and permanently stored in the DEQ CEDS 2000 database on a daily basis. Turnaround time from sample arrival at DCLS to receipt of analytical data varies from 48 hours to 21 days (90 days for clean trace metals), depending upon the parameter and sample type.

Sediment samples to be analyzed chemically and toxicologically by commercial labs (EPA-contracted laboratories prior to 2007) were held under refrigeration at DEQ Regional Offices and shipped to Richmond by courier on a weekly basis. Samples from the previous week were united and shipped via overnight air to EPA for transshipment to the appropriate contracted laboratories. Beginning in 2007, these sample types were shipped directly from DEQ to the responsible laboratories. Benthic infauna samples are preserved in (10%) buffered formalin as soon as they are collected and are maintained at DEQ Regional Offices until the end of the field season (late September or early October). Prior to 2005, they were then united at the DEQ Central Office in Richmond and shipped to EPA/GED for subsequent transshipment. Beginning in 2005 all benthic samples have been transferred directly from DEQ to the Benthic Ecology Laboratory at ODU for analysis. Formerly, turnaround time for the receipt of analytical results from EPA-contracted laboratories has varied from one year to two years or more, depending upon sample type and the associated EPA QA/QC procedures prior to the relay of data to DEQ. With the direct transfer of samples to DEQ-contracted laboratories initiated in 2007, maximum turnaround time for the receipt of results has been no more than 90 days for sediment chemistry and toxicity analyses, and six to seven months for the sorting, identification, enumeration, and calculation of indices of biotic integrity for benthic samples sent to ODU.

During National Surveys from 2000 through 2006, data related to fish community structure, epibenthic invertebrates, and bottom habitats, which were collected by VIMS trawl sampling, were immediately entered into their onboard SAS database during the process of collection. Most fish were returned immediately to the waters from which they were collected. Target fish species selected for chemical tissue analyses were individually labeled, wrapped in aluminum foil, and maintained on ice during transport to the VIMS Fisheries Science Laboratory. Once there, they were frozen and maintained until the end of the field season (early October). They were then shipped overnight, on dry ice, to EPA-contracted laboratories. Fish community, epibenthic macro-invertebrate and habitat data were united into a final report which VIMS sent to DEQ within 90 days of the end of the field season, generally in October or early November. Fish

samples collected by the DEQ field team were maintained on wet ice and returned to the regional office each evening, where they were packaged, frozen and maintained until shipment. During the NARS Survey in 2010, fish were shipped to the laboratories at least once every two weeks. Turnaround time for fish tissue chemical data and fish pathology data from EPA-contracted laboratories has generally been at least two years! Fish tissue samples are not collected during DEQ state design surveys.

As mentioned above, certain modifications to the sample collection, transport and analysis procedures were introduced during the 2005 – 2006 transition period. The 20 annual Chesapeake Bay and major tributary mainstem sites were sampled by the field team from the ODU Benthic Ecology Laboratory. Hydrographic profiles were recorded on field data sheets and copies were transferred to the DEQ Project Coordinator on a weekly basis. Sediment samples destined for DCLS analyses (particle size and TOC) or for EPA-contracted laboratories (metals, organics, and toxicity) were maintained under refrigeration and transferred to the DEQ Tidewater Regional Office, Virginia Beach, for transshipment on a weekly basis. Water column samples (nutrients, chlorophyll and TSS) were analyzed locally at the ODU Water Quality Laboratory in Norfolk, using approved CBP/EPA protocols, under the auspices of chemist Suzanne Doughten. Beginning in 2005, all benthic infauna samples from the Estuarine ProbMon Program were separated, identified and enumerated at the ODU Benthic Ecology Laboratory (BEL). Benthic samples collected and fixed by DEQ regional office field teams were maintained locally until the end of the field season, when they were shipped to the BEL/ ODU. The BEL provided and will continue to provide DEQ with complete taxonomic lists, enumerations of the taxa present, various calculated benthic community metrics, and final Benthic Indices of Biotic Integrity (B-IBI) for the Chesapeake Bay (CBP B-IBI - Alden, et al., 2002) and the Mid-Atlantic Region (MAR B-IBI - Llansó, et al., 2002a, b). In 2005 and 2006, and again in 2010, the Virginia Institute of Marine Science only performed trawl surveys of fish communities at the sites associated with the national (NCA) survey design. Sample maintenance and shipment was accomplished as previously described.

(iv) Frequency/Duration

As is typical of probabilistic survey programs, monitoring sites are normally sampled only once, after which new sites are randomly selected for the following year(s). In 2010, under the NARS/NCCA design, two sites were identified for revisits and were sampled a second time three to eight weeks later. Under the conditions defined by the earlier Coastal 2000 QAPP, sampling was to occur during the summer months, from 1 July through 30 September. This period also roughly coincides with the sampling "window" - July 15 through September 30 - defined for the use of the Chesapeake Bay Program's "Benthic Index of Biotic Integrity" [III-A-1b-3-6.pdf] (CBP B-IBI), which is utilized to evaluate the ecological health of the Bay's benthic community. The 2010 NARS/NCCA survey sampling window was dilated to 1 June through the end of September, but DEQ maintained the 1 July through 30 September sampling window, as previously defined, to assure validity of the CBP B-IBI.

DEQ's Estuarine Probabilistic Monitoring Program was proposed and developed as a permanent component of the agency's Ambient Water Quality Monitoring Program, and has been fully implemented since 2001. The resources provided by the original EPA Coastal 2000 Grant, which facilitated the initiation of the program in 2000, terminated at the end of September 2004. The decrease in federal support during the two-year transition period required a significant increase in state-provided resources as well as a corresponding reduction in parameter coverage at half of the sites sampled. DEQ has since evaluated the resource requirements for continuing the Estuarine ProbMon Program with supplemental §106 grant support and state funding. A reduced suite of parameters has been adopted, primarily the elimination of water quality samples from mid-depth and near-bottom, and of fish community and tissue chemistry sampling (see section on Estuarine Probabilistic Monitoring - 2013 and beyond, below).

(v) Quality Assurance Measures

DEQ's field and laboratory activities adhere to QA/QC protocols specified in the National Coastal Assessment Field Operations Manual [III-A-1b-3-2.pdf] (EPA 620/R-01/003) and the National Coastal Assessment Quality Assurance Project Plan July 2010 [III-A-1b-3-3.pdf] (EPA/620/R-01/002). In several specific cases early in the program, methodological variations were authorized by the Regional NCA QA Officer at EPA/ORD/GED, in Gulf Breeze, FL. Authorized departures included, among others, the use of submerged pumps and hoses for the collection of subsurface water samples and vacuum field-filtration of nutrient and chlorophyll samples. Both of these procedures are specifically described in the corresponding sections of the Tidal Water QAPP and SOP for Virginia's Chesapeake Bay Monitoring Program, the most recently approved editions of which can be found on the Chesapeake Bay Program WebPages. In addition, the 0.04 m^2 sediment samples collected for benthic infaunal analyses consist of a two-sample composite collected with a 6-inch Petite Ponar grab, rather than with the prescribed single 8-inch modified Young grab. A side-by-side comparative study [III-A-1b-3-7.pdf] performed in 2004-05 revealed no differences between the sample types for calculating the Chesapeake Bay Program B-IBI and associated metrics.

DEQ requires that a minimum of 10% QA samples (field duplicates, field blanks, etc.) be collected for all parameters from the near-surface depth and of sediment at estuarine ProbMon field sites. Normally, two QA sites are randomly selected annually for PRO and TRO and a single site for NRO, for a total of five QA sites among the 50 sites sampled (10%). During the 2005-2006 transition period six QA sites were distributed equally among the three sampling field teams: two sites each by PRO, TRO and ODU.

(vi) Data Management

Both samples and the resultant data collected within the National Coastal Assessment Program follow diverse pathways. Standard procedures for the transportation and delivery of samples to the Virginia Division of Consolidated Laboratory Services (DCLS), to the Old Dominion University Water Quality and Benthic Ecology Laboratories, and of sample shipment to EPA or other contracted laboratories were described above.

DEQ Regional Office monitoring personnel manually transcribe and enter field-collected water quality data (location, date, time, sample depths and temperature, DO, pH, salinity and photosynthetically active radiation profiles) from field sheets into DEQ's CEDS database as soon as they return from the field. The sample identifications and location, date, time and depth information are transmitted from CEDS to the DCLS LIMS database twice daily. This information is matched with that on the labels of samples received at DCLS. As mentioned above, if the information does not match exactly, any doubts are resolved immediately via e-mail and/or telephone communication between laboratory personnel and monitoring personnel at the DEQ Central Office or appropriate Regional Office. Field data collected by the ODU field team are recorded on field data sheets and copies are sent to the DEQ Project Coordinator weekly. The Coordinator QA's the field data sheets and the field data in the CEDS electronic database as soon as they are received. Any doubts relative to the information are clarified with the field team via e-mail or telephone within a week to ten days of collection.

Additional observations on site location and description, tidal stage, weather, habitat, sample collection and crew are recorded in field forms onsite by the participating field teams (PRO, TRO, NRO, plus ODU for national design surveys). Appropriate data related to site location and description are confirmed, and if necessary corrected or added, in the CEDS database. Xerox copies of field sheets are transmitted to the NCA Project Manager at the Central Office on a weekly basis. The Project Manager confirms their contents and resolves any doubts with the field personnel within forty-eight hours of receiving the field sheet

information. The Project Manager subsequently manually enters all information into electronic data files (Excel® spreadsheets) on a weekly basis. During national surveys, copies of these data files, as well as analytical results queried from the CEDS database, are transmitted to EPA/ORD GED or AED as soon after the end of each field season as is practical (generally by late October). Results from the ODU Water Quality Laboratory are provided to DEQ by the end of the calendar year and, following an additional intensive QA review, are communicated to EPA shortly thereafter. Benthic infauna results from the ODU Benthic Ecology Laboratory are provided to DEQ by June of the following year, and are communicated to EPA shortly thereafter.

The data flow and data management for water and sediment samples analyzed by DCLS follow pathways and turnaround times as described for the WQM Program in general. Analytical results are first Quality Assured by DCLS personnel and stored in their LIMS database. Results that are complete and certified there are subsequently shipped electronically, on a daily schedule, to the DEQ FTP site for upload into the CEDS 2000 database.

All data from locally (DCLS) analyzed samples reside in DEQ's CEDS 2000 database. A list of DCLS parameter group codes and individual analyte names and STORET codes is provided in the table "Matrix of Local Estuarine ProbMon Parameters" [III-A-0b.xls] from the annual MonPlan, under Program Code C2. The turnaround time, from receipt of samples at the DCLS laboratory until data arrives in the CEDS database, varies from 48 hours to 21 days (up to 90 days for clean trace metals) depending upon sample type. All analytical results receive a QA review at DCLS, prior to shipment to the DEQ database, and another QA review is performed by programmed algorithms (data range screenings, etc.) within the CEDS database. All Coastal 2000 / NCA data receive an additional, 'visual' review by DEQ's QA/QC Officer and by the agency NCA Project Manager, whether they are 'flagged' by the automated screening procedures or not.

Additional details of data management procedures are discussed in Chapter IV, Section E – Data Management, of this document.

(vii) Data Analysis / Assessment

The results from field measurements and locally (DCLS) analyzed estuarine ProbMon samples are stored in DEQ's CEDS 2000 database as soon as they become available. This occurs within a few hours in the case of field-measured parameters (temperature, DO, pH, salinity and photosynthetically active radiation profiles), which are entered into the database by monitoring personnel as soon as they return from the field to their respective Regional Offices. Analytical results from the DCLS laboratories are usually entered within 48 hours to 21 days, depending upon the analytes involved.

All data (in the CEDS database) for which water quality criteria and standards apply are included in the biennial data evaluation and/or assessment of water quality for DEQ's 305(b)/303(d) Integrated Reports and are also recorded in an appendix to each report. The analysis procedures utilized are described in the corresponding Assessment Guidance Manual for each report. Additional analyses and reporting of selected variables, including mapped and graphed statistical summaries, PDF curves, etc. are performed using methodologies similar to those described under the Freshwater ProbMon Program.

Data on the abundance, size and distribution of fish species collected during fish trawls are entered into VIMS' SAS database as the trawls are performed. Descriptive statistical summaries are calculated for each fish species and map plots with abundance symbols are constructed for selected, reasonably abundant species. Various measures of community structure, such as species diversity, species richness, and species

evenness are calculated for the dataset as a whole, and the resultant measures are plotted on site maps. During national surveys, VIMS reports these results to DEQ annually, within 90 days of completion of the field season.

NCA data transmitted to EPA are evaluated and summarized in periodic regional and/or national fact sheets and reports on the state of the nation's estuaries. (Copies of recent reports that include Virginia data are available at the U.S. EPA's Website on Oceans, Coasts & Estuaries [http://www.epa.gov/owow/oceans/nccr/]. The data analysis and assessment methods utilized for these EPA publications are described in the corresponding EPA/EMAP methods manuals.

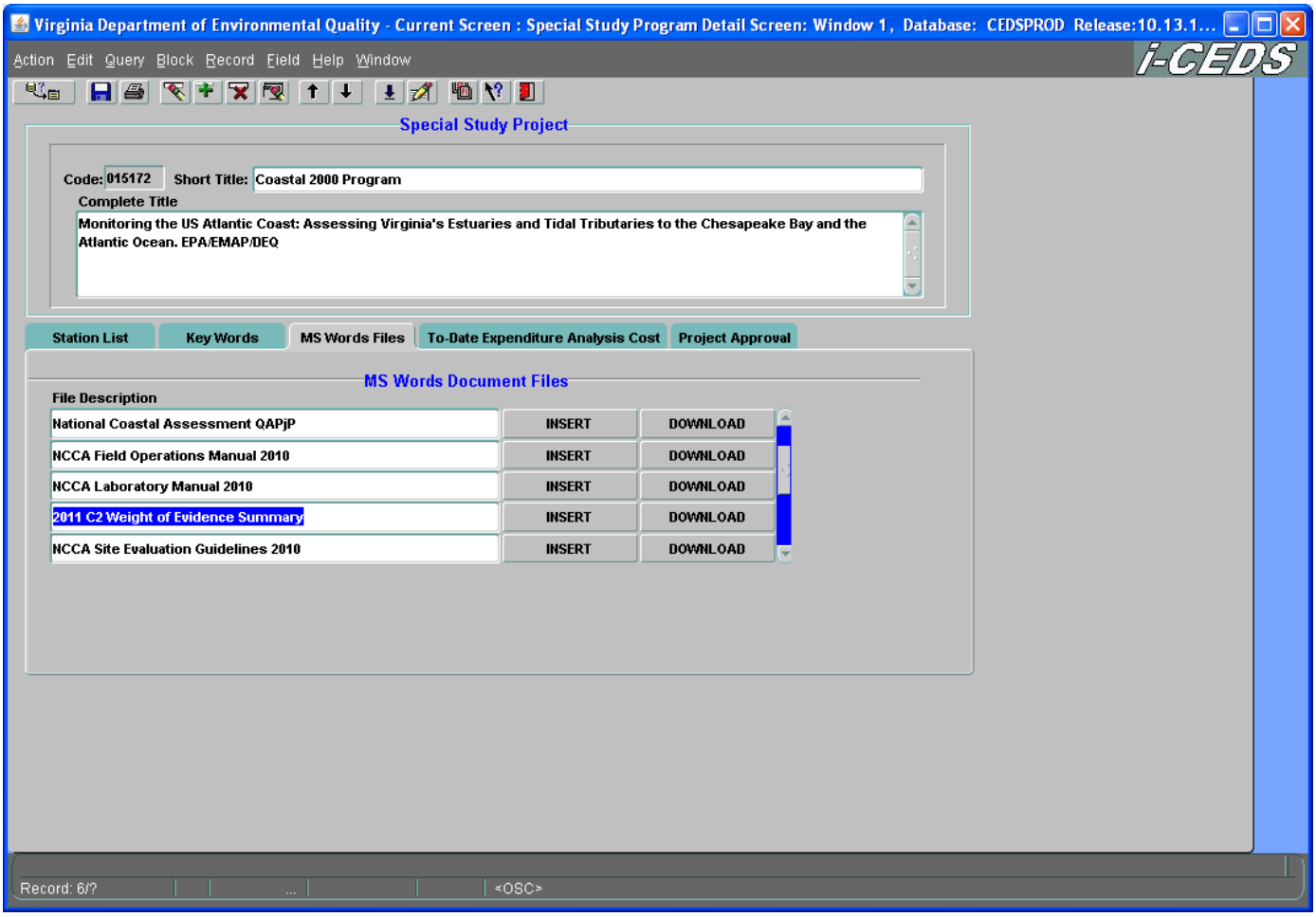
Once sediment chemical, toxicity and/or benthic infauna taxonomic data are returned to DEQ (from EPA-contracted laboratories via EPA/ORD, EPA/OW, or from BEL/ODU), site-specific sediment condition is assessed using a 'sediment quality triad' (SQT) based 'weight-of-evidence' methodology described in DEQ's Assessment Guidance Manual. Beginning with 2005 samples, the taxonomic data from benthic macro-invertebrate infauna samples were also analyzed utilizing multimetric Benthic Indices of Biotic Integrity (B-IBI). Data from those sites within the Chesapeake Bay drainage are analyzed using the Chesapeake Bay B-IBI described by Llansó (2002) [III-A-1b-3a-10a.pdf] and Llansó and Dauer (2002) [III-A-1b-3a-10.pdf]. For major Chesapeake Bay and tributary segments, Estuarine ProbMon results are integrated with those from the CBP Benthic Surveys for the assessment of the 'aquatic life' designated use, initially performed using the standardized methodology developed by Virginia, Maryland, the Interstate Chesapeake Bay Program, EPA Region 3 and Versar, Inc. of Columbia, MD for 305(b) purposes. This assessment methodology was first applied for the 2004 305(b) Reports of Virginia and Maryland, and was described in the final report "Decision Process for Identification of Estuarine Benthic Impairments" [III-A-1b-3a-11.doc] (Llansó, Vølstad and Dauer, 2003). A subsequent CBP B-IBI assessment, using a more recently developed statistical procedure, was incorporated into the 2006 305(b)/303(d) Integrated Reports of both states. This more recent benthic assessment protocol is currently (March 2013) under review by the CBP Criteria and Assessment Protocols Workgroup because of apparent discrepancies in 2012 assessment results. Resources have been designated for completing a recalibration of the CBP B-IBI prior to assessments for the 2014 305(b)/303(d) Integrated Water Quality Report. The most recent assessment procedures will be described in the corresponding Assessment Guidance Manual. All benthic data, from both the Chesapeake Bay and Atlantic coastal drainages, are also now analyzed using a more cosmopolitan B-IBI developed by Llansó and others (2002a, 2002b) [II-A-1b-3a-12a.pdf, III-A-1b-3a-12b.pdf] for estuaries of the Mid-Atlantic Region. This geographically more comprehensive methodology will be utilized to unite Chesapeake Bay and coastal data for a more general integrated statewide report on estuarine conditions.)

Fish-tissue chemistry results, once available from EPA-contracted laboratories, are also utilized to construct national 'report card' evaluations for selected contaminants in target fish species (summer flounder, spot, Atlantic croaker and white perch). The four primary target species that EPA selected for fish tissue chemical analyses are all migratory, however, and DEQ does not consider chemical concentrations in their tissues representative for characterizing local environmental conditions. Furthermore, Virginia's water quality standards pertain to edible fish tissues rather than to whole-fish concentrations. Consequently, a formal assessment procedure is not performed on the NCA fish tissue results. High concentrations of pertinent analytes in whole fish, however, do trigger a follow-up investigation by the Fish Tissue and sediment Monitoring Program (see below).

(viii) Reporting

As previously mentioned, the available data resulting from estuarine probabilistic monitoring are evaluated, assessed by a weight-of-evidence methodology following established guidance, and are incorporated into the agency's 305(b) Reports. The raw data (sediment chemistry, sediment toxicity, benthic results, and ancillary physical/chemical data) from each ProbMon site are all recorded in an Excel® workbook and stored in annual Weight of Evidence Summaries in the Special Studies Module of the CEDS database (see Figure III.B.2.c.1. below).

Figure III.B.2.c.1. "Special Study Program Detail Screen" of the Estuarine ProbMon (Coastal 2000 Program) from DEQ's CEDS database, illustrating the storage of weight of evidence summaries and associated data.



Because of logistical difficulties incurred by NOAA during the first field season of the Coastal 2000 Initiative, data for Virginia sites within the Chesapeake Bay mainstem were not collected that year. Sampling carried out during the 2005-2006 transition period and the 2010 NARS/NCCA survey improved the geographic coverage of this estuarine stratum, but 18 sites sampled within the Bay mainstem over a period of six years was not sufficient for a representative characterization. Once all data from the complete period (1 July - 30 September, 2001-2010) are available, DEQ will produce a summary report on the ten-year block of its Estuarine Probabilistic Monitoring Program. This Virginia Estuarine Condition Report will be modeled after the National Coastal Condition Reports produced by EPA (U.S. EPA, 2001, 2004, 2008, 2012). It will include descriptive graphical and statistical summaries and cumulative frequency

distributions for selected water quality, sediment and habitat variables for which data are available. This report, as well as the results from the 2011 and 2012 field seasons, will be integrated into DEQ's 305(b)/303(d) Integrated Water Quality Report in 2014.

The Fisheries Science Laboratory of the Virginia Institute of Marine Science (VIMS), which has performed the trawl sampling of fish communities for the program, produced a Five Year Summary Report [III-A-1b-3a-13.pdf] of its results in 2005. This report included descriptive statistics and mapped distributions and abundances of principal fish species, fish species richness, fish species diversity, etc. A related report on the possible Development of a Fish Community Assessment Tool [III-A-1b-3a-14.doc] was produced in 2005 by Dr. Stephen McIninch and Dr. Greg Garman of the Center for Environmental Studies, Virginia Commonwealth University. They evaluated the use of fish community data from approximately 230 NCA probabilistic sites sampled for fish during the first five years of the program for the possible development of an estuarine fish IBI. Their general conclusions were that the variations in the abundance and diversity of the estuarine fish species sampled were in response to differential preferences, primarily to salinity and secondarily to water depth and clarity. In addition, the sampling method used (otter trawl) and the restricted time frame of sampling (summer) did not provide adequate measures of community structure. Not enough is yet known about the metrics related to structure and function of undisturbed communities or how the metrics respond to various types of degradation and/or stress. Their recommendations for future development of a fish IBI were (1) to ensure a representative sample of the fish community by employing multiple gear types/sampling protocols, [and supposedly in a variety of seasons], (2) to obtain more data on fish communities associated with known degraded habitats and/or water quality impairment conditions, (3) examine the potential for analysis of juvenile populations in relation to stock assessment and, (4) focus on fish communities in freshwater and oligohaline waters where benthic invertebrate diversity and abundance is low and benthic IBI inefficient.

(ix) General Support and Infrastructure

The initial level of EPA grant support (CR-828544-01) for the Coastal 2000 Initiative, $200,000 annually from 2000 through the summer of 2004, provided for the purchase of field equipment and training of field personnel and permitted the establishment of a successful estuarine probabilistic monitoring program in Virginia's coastal waters. The continued availability of low-cost analytical services via EPA national contacts during the two-year transitional period allowed DEQ to continue sampling at 50 sites annually in 2005 and 2006, in spite of reduced federal support ($100,00/yr). However, even when those resources were complemented with agency general funds, it was necessary to restrict parameter coverage at a subset of sites. Contracted fish trawl surveys and the subsequent chemical analyses of fish tissue were only carried out at the sites from the national survey design that were sampled during that period.

DEQ has evaluated the estimated costs of continuing the program with state funding, under several restructuring scenarios. The past budget for collecting and analyzing the complete suite of NCA parameters at 50 probabilistic sites has been approximately $200,000 annually (~$4000/site), including EPA's in-kind services contributions for sample analyses at nationally contracted laboratories. This figure does not include significant DEQ contributions in the form of human resources and logistical costs for collecting samples.

DEQ has managed to continue the Estuarine ProbMon Program with 50 probabilistic sites per year since 2007 by integrating resources from agency general funds, federal §106 grant targeted supplements, and on occasion Chesapeake Bay Program grant funds, and by eliminating fish trawls and fish tissue analyses from the design. In 2010, by temporarily suspending the normal state estuarine design and with NARS/ NCCA

resources and extensive EPA National and Regional support, the agency was able to carry out the near-shore oceanic survey mentioned above.

(x) Estuarine Probabilistic Monitoring - 2013 and Beyond

In the early spring of 2004, prior to the announcement of the two-year NCA grant for the 2005-2006 transitional period, DEQ formed an estuarine probabilistic monitoring workgroup. This workgroup reviewed the past performance of the program up to that time, found it to be a valuable asset in the characterization and assessment of estuarine waters, and discussed possible options for continuing the program with reduced resources. Among various alternatives considered, the possible reduction of the parameter suite previously monitored by the program and/or a reduction in the number of sites sampled each year were found to be viable options.

The single most expensive activity during the initial seven years (2000-2006) of the Estuarine Probabilistic Monitoring Program was the collection and analysis of fish community data and the subsequent chemical analyses of organic and inorganic contaminants in tissues from target fish species. In addition, both the tissue chemical results and the fish community data were considered to be of limited value for site characterizations because the principal target species were all migratory, and trawl sampling on a single date is not representative of local fish community diversity. Between trawl collections (contracted out to the Virginia Institute of Marine Science - VIMS) and tissue analyses (at EPA-contracted laboratories), average costs had approached $2000 per site. The national EPA contract had provided analytical services at costs considerably below what DEQ could arrange locally. Continuing to sample and locally analyze fish communities and fish tissue at 50 sites per year would cost an estimated $135,000 annually. Suspending the collection and analyses of fish communities/target species would provide a major (and necessary) reduction in program costs under restricted resource availability.

Another expensive activity included in the program has been the complete analysis of the Sediment Quality Triad (SQT). The SQT consists of (1) sampling, identifying, enumerating, and evaluating the community of benthic organisms within the sediment, (2) the testing of sediment for toxicity (acute 10-day survivorship tests, initially with *Ampelisca abdita,* and more recently with *Leptocheirus plumulosus*), and (3) the chemical analyses of metal and organic contaminants in the sediment. If resources were to become limiting, a tiered sampling / analytical regime would also present a viable option for reducing expenses. Such an approach would consist of using the benthic community analysis and/or the toxicity test as screening tools, prior to investing in chemical analyses.

One product of the workgroup's deliberations was to integrate selected elements of the Chesapeake Bay Program's probabilistic benthic monitoring with the Estuarine ProbMon program within the Chesapeake Bay drainage. The proposal for this integration was summarized in the document "Aquatic Life Use Assessment Strategy for Virginia Chesapeake Bay Minor Tidal Tributaries" [III-A-1b-3a-12.pdf] submitted to EPA Region 3 in June of 2004. The resource sharing introduced by the integration of these two programs resulted in significant advantages to the Chesapeake Bay Program, to the Estuarine ProbMon Program and to the 305(b) Water Quality Assessment process.

(a) Chesapeake Bay Program
   i. Increase the number of B-IBI samples for the characterization of the minor tidal tributaries (at no extra resource expenditure).
   ii. Associate the Benthic IBI data within minor tidal tributaries with other elements of the Sediment Quality Triad (SQT) - toxicity and (possibly) chemical contaminants - collected by the Estuarine ProbMon program.

iii. Associate the Benthic IBI data within minor tidal tributaries with additional water column parameters – nutrients, chlorophyll, bacteria, clean metals, photosynthetically active radiation (PAR) and field parameter profiles – not normally collected during CBP benthic sampling.

(b) Estuarine ProbMon Program

i. Under limited resources, a second screening element could be added to the SQT (B-IBI + toxicity tests) prior to investing resources in the (expensive) chemical analyses of sediment metal and organic contaminants.

ii. Adding a B-IBI score at these sites would also reduce the potential need to consider performing toxicity tests on two different species, thus reducing per site resource requirements.

iii. A possible increase in the annual number of probabilistic sites in minor tidal tributaries within the CB drainage.

(c) 305(b) Assessment

i. In minor tidal tributaries where insufficient numbers of observations were available for normal CBP B-IBI assessment, associating the B-IBI evaluation with sediment toxicity test results and the water column data would provide the basis for a more robust 'weight of evidence' assessment for minor tidal tributary segments, even when chemical analyses of the sediment are not carried out.

ii. The complete SQT (including chemical analyses) would be performed whenever the B-IBI and/or the toxicity test results indicated a potential water quality problem. The chemical analysis of frozen sediment samples would be initiated immediately if:

1. Significant toxicity (mortality) was observed in the toxicity text of sediment from the same site.
2. Significant benthic degradation, as indicated by either the CBP B-IBI or the Middle Atlantic Region (MAR) B-IBI, was observed at the site. In the case of the CBP B-IBI, subsequent application of the discriminant function phase of the 'Benthic Diagnostic Tool' would also be required to confirm that the confidence for including the benthic results in the 'Contaminant Related' group was at least 75%.

In reality, through the efficient integration of financial and human resources, DEQ has managed to preserve its state design Estuarine Probabilistic Monitoring Program in its entirety (minus fish community and tissue analyses). With the exception of 2010, when state and federal (NARS/NCCA) resources were used to conduct a 50-site near shore oceanic survey, the agency has attained its goal of 50 sites annually. With the exception of an occasional lost sample, all three elements of the sediment quality triad have been evaluated at all sites. Weight of Evidence aquatic life use (benthic invertebrate) assessments have been performed at 577 estuarine and 50 near-shore oceanic sites during the first twelve years of the program. Fish community analyses and fish tissue chemistry have never been included as state objectives. In the future, additional direct federal support for this program (NARS/NCCA in 2015, 2020 and beyond), or additional resources provided through the normal §106 grant process, would conceivably permit the collection of fish community data and the analysis of fish tissue at selected sites and/or permit an increase in the number of sites sampled each year (see the following section on Virginia's Participation in Rotating National Probabilistic Surveys).

Under current resource availability (calendar year 2013), DEQ's Estuarine Probabilistic Monitoring Program will continue to include the components and activities specifically summarized below. Other major elements included in the design, core and supplemental indicators, frequency/duration, quality

assurance, data management, analysis, assessment and reporting, and general support and infrastructure will remain unchanged except where specifically noted.

1. **Design** –

   DEQ has managed to maintain the previously established agency design structure, with 50 completely random (equal probability) sites annually, distributed in embayments and minor tidal tributaries of the Chesapeake Bay drainage (70% = 35 sites) and in Atlantic Coastal drainages (30% = 15 sites). If required by future resource constraints, Atlantic Coastal monitoring might be suspended except when additional funds were available for scheduled national surveys (2015, 2020, etc.). The annual number of sites consequently would be reduced to approximately 35.

2. **Core Indicators** –

   a. Contracted fish trawl surveys and the chemical analysis of fish tissue would continue to be suspended except when additional federal funds (possibly NARS/NCCA in 2015, 2020, etc.) permit their inclusion.

   b. Sediment Quality Triad: All sediment sample types (particle size/TOC, toxicity, chemistry, and benthic infauna) will be collected at all sites monitored.
      i. **Particle size and TOC** analyses (DCLS) are carried out immediately for all sites.
      ii. **Toxicity tests** (10-day acute survivorship tests, originally with *Ampelisca abdita*, more recently with *Leptocheirus plumulosus* - externally contracted services) are performed for all sites within established (30-day) holding time requirements.
      iii. **Benthic infauna analyses** (ODU Benthic Ecology Laboratory) will be carried out for all sites. Samples are normally fixed in 10% formalin, accumulated, and delivered to the laboratory at the end of the field season (late September or early October).
      iv. **Chemical analyses:** Sediment samples intended for chemical analyses are maintained frozen and are shipped to the contracted laboratory in two batches, one in mid-August and the other at the end of the field season (late September or early October). Resources available through calendar year 2013 have been sufficient for the complete chemical analyses of sediment samples from all 50 sites each year.
      v. **Under reduced resources:** If resources become limiting in future years, a tiered analytical approach may be implemented. Once both toxicity and benthic results are available, the samples selected for chemical analyses can be shipped as a single batch to the responsible laboratory. The decision to analyze or not would be based on:
         1. Analyze chemically if significant changes in survivorship/mortality are observed in toxicity tests. (The toxicity results should be available within 60 days of sample collection.)
            Analyze chemically if significant benthic degradation is indicated by either of the following indices. (Benthic IBI results are not expected to be available until approximately 9-11 months following sample collection.)
            a. Within the Chesapeake Bay drainage - Chesapeake Bay B-IBI score ≤ 2.7 (Supplemental evaluation, applying the discriminant function of the benthic 'Diagnostic Tool', would provide the inclusion probability for being in the 'contaminant group')
            b. Atlantic Coastal estuaries - Mid-Atlantic B-IBI score < 3.0

2. Archive sediment chemistry samples without analyzing if neither condition (Items 1 and 2 above) is satisfied.

c. Hydrographic profiles (temperature, pH, DO, salinity/specific conductance and PAR) will be measured at all sites. Physical samples for all other water column parameters (nutrients, TSS, chlorophyll) are collected at near surface (~ 0.5 m) depth.

d. Supplemental (non-NCA) parameters: Bacterial samples (fecal coliform, *E. coli*, and genus *Enterococcus*) are collected at all sites. When resources are available, dissolved and total trace metals will also be collected and analyzed at probabilistic estuarine sites. Additional supplemental parameters may be included as environmental requirements and resources dictate (*e.g.*, dissolved petrogenic PAHs in the event of petroleum spills, etc.).

Contact: For further information on the Estuarine Probabilistic Monitoring Program contact:

Donald H. Smith, Ph.D.
629 East Main Street
Richmond, Virginia 23219
(804) 698-4429
Donald.Smith@deq.virginia.gov

(4) Participation in Rotating National Probabilistic Surveys

Over the past two decades, the EPA Office of Research and Development (ORD) has developed and refined the design of probabilistic survey sampling for the purpose of environmental characterizations and assessments. The resultant Environmental Monitoring and Assessment Program (EMAP), and regional elements (REMAP) thereof, have focused on various aspects of the nation's natural resources, including various classes of aquatic resources, landscape ecology, the impacts of urban development. Various regional programs, such as EMAP West and the Mid-Atlantic Integrated Assessment (MAIA) project have already successfully integrated data from state, regional and national environmental monitoring programs into regional assessments, have reported upon past results, and will continue to do so in the future. Similar, nationwide efforts have resulted in a series of reports on the condition of the nation's aquatic resources: National Coastal Condition Reports I (U.S. EPA, 2001), II (U.S. EPA, 2004), III (U.S. EPA, 2008), IV (U.S. EPA, 2012), and V (in preparation, 2013), the Wadeable Streams Assessment Report (U.S. EPA, 2006 - http://www.epa.gov/owow/streamsurvey/). The 2008-2009 National Rivers and Streams Assessment (NRSA) is currently undergoing review in preparation for the draft report that is scheduled to be released in Early 2013, and the National Coastal Condition Report V, based on the 2010 survey, is also in preparation and expected later in 2013. Additional studies currently in progress are developing and refining comparable methodologies for monitoring and assessing other aquatic resource classes such as 'Great Rivers', 'Lakes and Reservoirs', and 'Wetlands'.

By late 2005 EPA/ORD had developed a tentative schedule for implementing nationally-organized, rotating surveys of five separate subclasses of the nation's waters (Table III.A.2.d-1, below, and linked Schedule of National Surveys [III-A-1b-3-4c]): (1) Coastal (estuarine) waters, (2) Streams, (3) Lakes and reservoirs, (4) Rivers, and (5) Wetlands, although streams and major rivers are being integrated into concurrent surveys and a single integrated report on the 2008-2009 National Rivers and Streams Assessment (NRSA) is currently undergoing review in preparation for the draft report that is scheduled to be released in Early 2013. Although the table covers only the period for federal fiscal years 2006 through 2018, several phases of the proposed rotation schedule have already been completed or are currently in progress and the intent is

apparently to continue the rotation schedule beyond the 13 years represented in the table. The Commonwealth of Virginia has actively participated in several previous efforts, is currently participating in the design phase for the 2013 field season for the 'Rivers and Streams' survey, and intends to participate in as many future activities as resources allow. If past results and the experience gained are any indication, the integration of the national program's objectives and resources into ongoing elements of DEQ's Water Quality Monitoring Program will provide significant gains for both. It is expected that the periodic (annual, considering all five resource classes) injection of additional federal resources and updated/improved methodologies and technologies into established and/or developing DEQ programs, will expand the list of core indicators included, will facilitate their interpretation, and will improve the geographic coverage and the efficiency of monitoring of each class of water resource.

(1) **Coastal:** As previously described, DEQ's Estuarine Probabilistic Monitoring Program has actively participated in the Coastal 2000 Initiative and the National Coastal Assessment Program, with generous federal support, from 2000 - 2006. Significant restructuring and some reduction of coverage by the agency's Estuarine Probabilistic Monitoring Program became necessary in 2007, due to the reduction of available resources. The agency was able to return to complete geographic and parametric coverage at 22 estuarine sites and for all but fish tissue chemistry at 50 near-shore oceanic sites with the infusion of additional federal NARS/NCCA resources in 2010. Hopefully this can be repeated in 2015 and at five-year intervals thereafter.

Table III.A.2.d-1 - Proposed Rotational Schedule for Conducting Statistically-Valid Surveys of the Nation's Waters (EPA/ORD, December 2005).

	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18
Coastal	Lab,data	Report	Research	Design	Field	Lab,data	Report	Research	Design	Field	Lab,data	Report	Research
Streams	Report	Research	Design	Field	Lab,data	Report*	Research	Design	Field	Lab,data	Report	Research	Design
Lakes, reservoirs	Design	Field	Lab,data	Report	Research	Design	Field	Lab,data	Report	Research	Design	Field	Lab,data
Rivers	Research	Design	Field	Lab,data	Report*	Research	Design	Field	Lab,data	Report	Research	Design	Field
Wetlands	Research	Research	Research	Research	Design	Field	Lab,data	Report	Research	Design	Field	Lab,data	Report

(2) **Streams:** DEQ's Freshwater Probabilistic Monitoring Program has been active in free-flowing streams and rivers since 2001. During the 2004 field season DEQ took advantage of the opportunity to participate in a national probabilistic survey of wadeable streams within the EPA EMAP Program (see previous section on Probabilistic Monitoring of Free-flowing Freshwaters). Resources provided by this participation facilitated the investigation of several potential improvements to DEQ's freshwater probabilistic program. Having already participated for the field seasons of 2008-2009, the agency has already initiated its participation in the national 'Streams' and 'Rivers' surveys for 2013-2014.

(3) **Lakes and Reservoirs:** Although DEQ's Lake Monitoring Program (Section III-B-2) has not traditionally included probabilistic survey elements, the agency actively participated in the design of and preparations for the national lake survey during the summers of 2007 and 2012. The infusion of resources and the experience gained in the process may stimulate the incorporation of probabilistic monitoring as a permanent element of the agency's Lake Monitoring Program.

(4) **Rivers:** Although DEQ applies differing methodologies to the monitoring of wadeable streams and larger streams and rivers, the two resource classes are integrated into the same Free-Running Freshwater Probabilistic Monitoring Program. Please refer to paragraph (2) above and see the earlier Section III-A-2-b on Probabilistic Monitoring of Free-flowing Freshwaters. EPA sponsored a 'Survey of the Nation's Rivers' Planning Meeting in January 2007. The subsequent survey targeted the nation's non-wadeable rivers and

streams during the summers of 2008 and 2009. DEQ attended the initial planning meeting and participated actively in both field seasons. Expectations are that federal support and training for the program, as well as associated methodological advances, will help improve the agency's current free-flowing freshwater probabilistic program.

(5) **Wetlands:** DEQ's developing Wetlands Monitoring Program, as described in Section III-B-6 and in the agency's final "Wetland Monitoring and Assessment Strategy" document, has relied extensively on probabilistic survey methods. Although specific stressor indicators and monitoring methodologies are still under development, on both national and local level (see Table III.A.2.d-1, above), DEQ actively participated in the preparations for and in field work of the National Wetlands Survey in 2011 and anticipates participation in the 2016 survey as well!